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DEALING WITH THE POLICIES OF ORBITAL DEBRIS

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ABSTRACT

There has been much discussion of the material problems which space debris poses, but little serious analysis of the legal and policy issues which this hazard raises. All man-made debris orbiting in outer space (space debris) is generated by manned and unmanned space programs of the world's space-capable nations. While meteoroids are a source of naturally occurring space debris, they are not considered a serious hazard. Space debris poses a much greater risk of harm to manned and unmanned space activities than its natural counterpart. The meteoroid population is essentially consistent, while the quantity of space debris, so far, is steadily increasing. Also, the presence of meteoroid populations has already been accounted for in spacecraft design. Space debris poses a variety of hazards to space activities and to the integrity of the outer space environment.

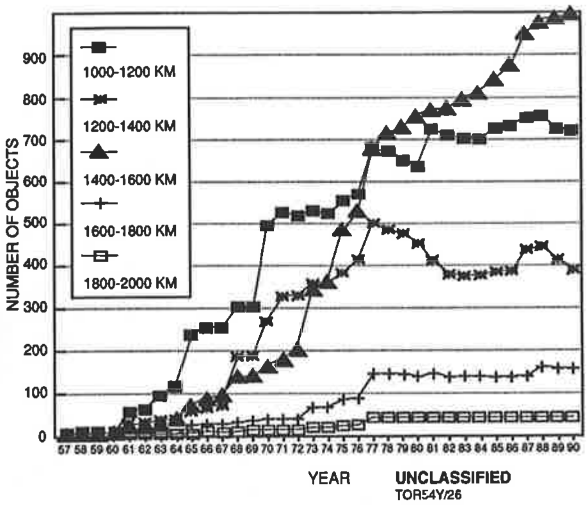

Figure 1. Debris Growth Rate.

1. INTRODUCTION

Space debris is becoming a major concern for many of the space systems presently considered. This concern is due to a combination of fundamental issues. The debris environment is a dynamic process in which fragmentation due to collisions create additional objects of different sizes. Some of the small particles are washed out by solar pressure and some of the larger particles deorbit due to aerodynamic drag, if they are in a low orbit. Figure 1 shows the growth rate of the debris environment, since 1957, as a function of altitude. While the size distribution as a function of altitude, of the total effect, is yet unknown, it has been estimated that a uniform increase of 5% over the entire size range envelopes all uncertainties. Figure 2 provides a distribution of objects as a function of altitude. Immediate detection of meteoroids and space debris is extremely important for successful space missions, particularly those of long duration. Impacts may cause damage to manned habitable modules, sensors, reflective or refractive optics, etc. Figure 3 shows recent damage (1992) to a Shuttle window. The diameter of the crater is ~7 millimeters.

Space-based systems exposed to the environment of Low-Earth Orbit (LEO) will avoid catastrophic failures only if the materials from which they are comprised provide a "shield" against the effects of continuous hypervelocity impacts. Extensive research has been conducted to characterize the effects on materials subjected to hypervelocity impacts by large masses. Even though the large mass impactors carry the highest probability of precipitating a catastrophic event, the number of large mass objects which might be encountered by an exposed surface in LEO is believed to be quite small.

2. PROGRAMMATIC ISSUES

Among the many concerns faced by a program manager is the issue of space debris. Space debris or orbital debris can be defined as "any man-made Earth orbiting object which is nonfunctional with no reasonable expectation of assuming or resuming its intended function or any other function for which it is or can be expected to be authorized, including fragments and parts thereof" (1). The manager's concern for orbiting debris is twofold: minimizing the debris that his satellite(s) will generate, and having his satellite(s) survive during their mission, any encounters with space debris. The first of these must abide by the November 1989 Directive on the National Space Policy (2). This states: "... all space sectors will seek to minimize the creation of space debris. Design and operations of space tests, experiments and systems will strive to minimize or reduce accumulation of space debris consistent with mission requirements and cost effectiveness. The United States government will encourage other spacefaring nations to adopt policies and practices aimed at debris minimization."

The second concern for the manager relates to what altitude, inclination and shielding should be placed on the satellite; all factors which affect the lifetime, fuel efficiency and performance of the craft. Trade-off studies will be conducted to optimize the performance and lifetime, maximize the shielding and fuel efficiency, while staying under a specified launch weight. These factors frequently are mutually exclusive.

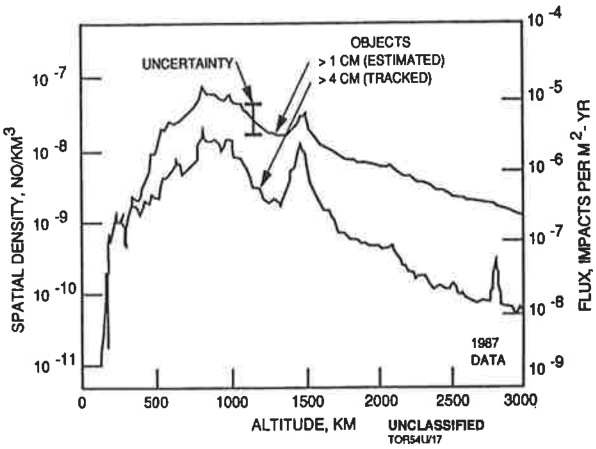

Figure 2. Altitude Distribution of Space Objects.

Figure 3. Recent impact damage to Shuttle window.

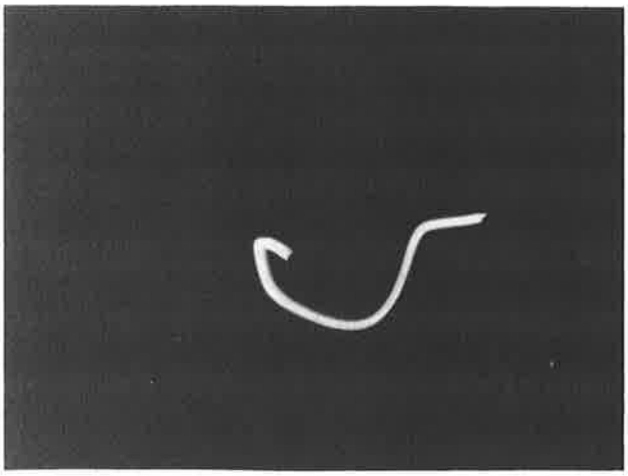

Figure 4. Object liberated by upper stage and visible to Shuttle crew.

Studies and modeling of the debris environment have taken place over a long period of time. NASA developed a model of the debris environment in 1984, and it was updated and verified in 1991 using information obtained from observations and returned space hardware (3). This revised model, differs from the previous one in that it includes those objects that measure 1 to 10 cm diameter. These objects are large enough to cause significant damage to a structure but too small to be readily detected and, therefore, avoided. Figure 4 shows an object liberated from an upper stage and observed by the Shuttle crew. It is estimated that this object is three meters long, with a cross-section of nine centimeters. It is estimated that the object was nearly one kilometer below the Shuttle when the photograph was taken. It must be noted that the revised model has lowered the rate at which objects are expected to multiply - from 5% annually to about 2%. The uncertainty of the estimates has also been reduced (4).

3. REQUIRED ACTION

The four classes of space debris: inactive payloads, operational debris, fragmentation debris and microparticulate matter could precipitate collisions and interference. If the proliferation of space debris is not brought under control soon, the probability of the occurrences of a space debris risk event will steadily increase with each launch. The problems posed by space debris have not been dealt with directly in international law, particularly in the five space law treaties which form the basis for regulation of human activities in outer space. Some states and international organizations, both governmental and non-governmental, have begun to address these issues and to develop appropriate policies and laws. Although laudable, these efforts are not sufficient. Due to the physical nature and legal status of the outer space environment, action on an international scale is necessary to deal efficiently and effectively with the space debris problem.

A regime for effective control of the outer space environment is strongly suggested, and is based on three guiding principles:

a) International responsibility for the protection of the outer space environment entails a global approach, not a State-centered one. Each State has an interest in and a right to an outer space environment free of space debris, a corresponding duty to protect that environment and an obligation to provide compensation for damages resulting from its breaches of that duty.

b) Recognizing State preference for space object placement in certain LEO's due to the technical and economic advantages they afford and considering that manned space activities in LEO are restricted to altitudes between 200-1000 km, due to physical and biological factors. LEO may be considered a limited natural resource of vital importance for a variety of space activities. Activities in LEO and in GEO require coordination and planning to ensure optimum use.

c) The environmental approach, provides the foundation for a regulatory system, with a long-term objective of total elimination of space debris.

4. PROPOSED PRINCIPLES OF REGULATION

To be effective, the regime should consist of general principles of international law for facilitating the regulating of space debris and an organizational structure for implementing it. The general principles are intended to fill gaps in the international law of outer space as it pertains to space debris.

Definition - Space debris means those man-made objects in outer space deemed to be valueless, as evidenced by an absence of operational control, and includes inactive payloads, operational debris, fragmentation debris and microparticulate matter.

Jurisdiction and Control - Removal of space debris is permissible without the consent of the State of registration, if that State will not or cannot undertake or authorize its removal.

International Responsibility - All States are responsible internationally for the space debris they create and shall provide compensation for damage caused by their space debris.

4.1 Registration

Launching States shall record in the UN register, as soon as technologically possible, information on the launching of all actual and potential space debris objects, whether or not they are launched into earth orbit or beyond, and shall provide any additional information necessary for assisting the detection of these objects.

All space objects, including potential space debris objects, shall be marked in order to best facilitate their prompt and accurate identification.

4.2 Liability

The term "damage" includes damage caused by space debris to the outer space environment per se, the Moon and other celestial bodies.

If a space debris object is identifiable, the State launching that object shall be absolutely liable to pay compensation for any damage caused by that object to any active payload. If the space debris object cannot be identified, a fund provided by all launching States shall pay compensation for any damage caused by that object, on the basis of absolute liability.

4.3 Prohibitions

- Military or other uses of space debris are prohibited.
- Creation of space debris for use as an environmental modification technique is prohibited.

4.4 Regulatory Plan

Space debris may be controlled by preventing its creation, by removing it from outer space, or avoiding situations conducive to the occurrence of risk events. Such a plan should stress prevention as the primary method of control and accept removal as a secondary, or alternate procedure. Plans should be flexible enough to the rapid pace of science and technology development, yet specific enough to indicate clearly the scope of permissible activities.

States shall in good faith use their best technological efforts to develop operational procedures and technical design strategies to prevent creation of space debris.

4.5 Comments

All States should have an opportunity to contribute to the development of general policy and overall objectives. The desired structure for an international organization monitoring and regulating policies dealing with orbital debris could be achieved by combining various elements of existing international organizations, governmental and/or non-governmental.

5. SUMMARY

The greatest hazard facing human activities in outer space is space debris, not naturally occurring debris such as meteoroids. Space debris poses dangers to spacecraft and astronauts (cosmonauts) alike. The space debris hazard has already introduced safety issues for consideration by national space agencies, spacecraft designers, space station manufacturers, scientists and insurance underwriters.

Space debris presents a significant hazard to current space systems, and a risk to future manned spacecraft and to space stations. It may render certain portions of near-earth space unusable. Space debris is *virtually impossible* to remove once it has been placed in orbit. If present trends continue, it will not be safe to carry out activities in certain sectors of outer space, primarily LEO and GEO.

6. ACKNOWLEDGEMENTS AND REFERENCES

A few people have written concerning the legal and policy implications of space debris. Foremost among these is Howard A. Baker, author of the 1989 book, Space Debris, Legal and Policy Implications, which was written originally in 1988 at McGill University's Institute for partial fulfillment of the requirements for the degree of Master of Laws (LLM) Howard Baker also participated as a contractor in the 1990 OTA (Office of Technology Assessment of the U.S. Congress) background paper entitled: Orbiting Debris, A Space Environmental Problem, and reviewed the test of the 1992 AIAA Special Project: Orbital Debris Mitigation Techniques, Technical, Legal and Economic Aspects.

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(3) GAO/IMTEC-92-50 Space Debris Threatens Stations Safety and Costs, June 1992.

(4) Asker, J.R., "Space Station Designers Intensify Effort to Counter Orbital Debris", *Aviation Week & Space Technology* pp. 68-69, 08 June 1992.